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Jawaharlal Nehru

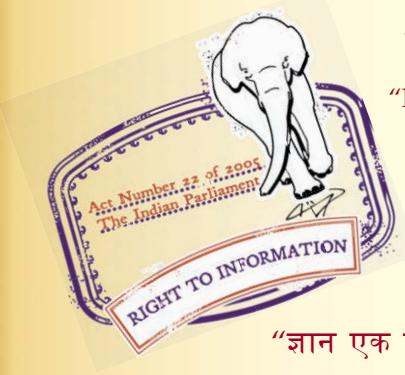
“Step Out From the Old to the New”

IS 11989 (1986): Compressed Air Dryers [MED 22: Compressor, Blowers and Exhausters]

“ज्ञान से एक नये भारत का निर्माण”

Satyanaaranay Gangaram Pitroda

“Invent a New India Using Knowledge”



“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”

Bhartṛhari—Nītiśatakam

“Knowledge is such a treasure which cannot be stolen”





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*Indian Standard*

**SPECIFICATION FOR  
COMPRESSED AIR DRYERS**

**1. Scope**— Specifies reference conditions, acceptance test methods and the most important characteristics data of different dryers.

**1.1** It is applicable to compressed air dryers working in the pressure range of 0.18 to 40 MPa (1.8 to 400 bar), but excluding:

- a) liquid absorption types,
- b) cooling with after-cooler, and
- c) over-compression.

**2. Definitions**— For the purpose of this standard, the following definitions shall apply.

**2.1 Moisture Content  $e_w$  (grams per cubic metre)**— The ratio of water and water vapour by mass to the total volume.

**2.2 Vapour Concentration (grams per cubic metre)**— The ratio of water vapour by mass to the total volume.

**2.3 Vapour Ratio**— The mass ratio of water vapour (in grams) to dry air (in grams).

**Note**— It is not recommended to express the vapour ratio in parts per million (ppm). When parts per million are used (at very low dew points), it shall be clearly stated whether it is on a mass or a volume ratio basis.

**2.4 Partial Pressure (millibars)**— The absolute pressure exerted by any component in a mixture.

**2.5 Saturation Pressure (millibars)**— The total pressure at which moist air at a certain temperature may coexist in neutral equilibrium with a plane surface of pure condensed phase (water or ice) at the same temperature.

**2.6 Relative Vapour Pressure**— The ratio of the partial pressure (millibars) of the water vapour to its saturation pressure (millibars) at the same temperature.

**2.7 Relative Vapour Concentration**— The ratio of the actual water vapour concentration (grams per cubic metre) to its saturation value (in grams per cubic metre) at the same temperature.

**2.8 Relative Vapour Ratio**— The ratio of the actual vapour ratio (see 2.3) to the saturation vapour ratio at the same temperature.

**2.9 Dew Point (Degrees Celsius)**— The temperature, referred to a specific pressure, at which the water vapour begins to condense.

**2.9.1 Atmospheric dew point**— The dew point measured at atmospheric pressure.

**Note**— Atmospheric dew point shall not be used in connection with compressed air drying.

**2.9.2 Pressure dew point**— The dew point measured at the actual pressure, which shall be stated.

**2.9.2.1 Pressure dew point, nominal value**— The dew point obtained in a dryer, which shall not normally be exceeded, when operating under the stated conditions.

**2.10 Capacity of a Dryer**— The capacity of a dryer is the volume flow rate referred to a standard reference atmospheric condition of an absolute pressure of one bar and a temperature of 20°C.

**2.10.1 Volume flow at dryer inlet**— The maximum volume of flow air accepted by the dryer (under the conditions given in 2.10) including air required for regeneration, pressuring or cooling purposes.

**2.10.2 Volume flow at dryer outlet**— The maximum volume flow of air delivered by the dryer (under the conditions given in 2.10) available for use, that is, after purge air, pressurizing air and cooling air flows have been deducted.

**2.11 Desiccant** — A substance with the ability to retain water without change of state (for example, silica gel,  $\text{SiO}_2$ , activated alumina). The term thus excludes deliquescent substances.

**2.12 Absorption** — The attraction and adhesion of molecules in a gaseous or liquid phase to the surface of a solid.

**2.13 Desorption** — The driving off of water held by a desiccant.

**2.13.1 Regeneration** — Desorption and preparation of desiccant to enable it to enter a new period of operation.

**2.14 Absorption** — The process of attracting one substance into the mass of another so that the absorbed substance disappears physically.

**2.14.1 Liquid absorption** — The drying of air or gas by means of a liquid desiccant (for example, triethylene glycol or sulphuric acid).

**2.14.2 Deliquescence** — The spontaneous process whereby a soluble solid material absorbs water and becomes liquid.

**2.15 Sorption** — Absorption and adsorption considered jointly.

**2.16 Cooling** — The method of liquefying part of the condensable vapours by reducing the temperature.

**2.17 Overcompression** — The method of drying air by compressing it to a pressure higher than the intended working pressure.

### 3. Types of Compressed Air Dryers

#### 3.1 Absorption Dryers

**3.1.1** Compressed air dryers, which extract water vapour from the compressed air, where the absorbent combines chemically with the water vapour and goes into solution. The hydrous solution is drained off; the absorbent is normally not recovered.

##### 3.1.1.1 Liquid desiccant

##### 3.1.1.2 Deliquescent substances

**3.1.2 Absorption dryers** — Compressed air dryers, which extract water vapour from the compressed air by attraction and adhesion of molecules in a gaseous or liquid phase to the surface of a solid. The absorbent may be regenerated by removing the absorbed water.

##### 3.1.2.1 Heatless

##### 3.1.2.2 Directly heated

##### 3.1.2.3 Regenerative air heated

##### 3.1.2.4 Others

**3.2 Refrigeration Dryer** — Compressed air dryers, which extract water vapour by means of cooling with a refrigeration circuit.

##### 3.2.1 Water chiller

##### 3.2.2 Heat absorbing mass

##### 3.2.3 Direct expansion

##### 3.2.4 Flooded evaporator

### 4. Reference (Standard Rating) Conditions and Performance Rating Parameters

**4.1** Reference (standard rating) conditions and performance rating parameters are both necessary in defining the performance of an air dryer in comparing one make of dryer with another.

**4.2** The reference conditions in Table 1 shall form an invariable part of any statement that performance is option A or B also being quoted.

TABLE 1 REFERENCE CONDITIONS

(Clause 4.2 and Appendix B)

Quantity	Unit	Value	
		Option A	Option B
Inlet temperature	°C	35	38
Inlet pressure	bar	7	7
Inlet pressure dew point	°C	35	38
Cooling air inlet temperature	°C	25	38
Cooling water inlet temperature	°C	25	30
Ambient air temperature	°C	25	38

**4.3** The performance rating parameters in Table 2 shall form the second and variable part of such a statement.

TABLE 2 PERFORMANCE RATING PARAMETERS

(Clause 4.3 and Appendix B)

Quantity	Unit	Value
Outlet pressure dew point	°C	As specified
Outlet air flow	m <sup>3</sup> /h	As specified
Pressure drop across cooler	bar	As specified
Frequency of electrical power supply	Hz	As specified

**5. Data** — The data given in Appendix A shall be stated when specifying and inspecting a compressed air dryer. Other relevant details such as explosion proof properties, hazardous area, etc, shall also be included.

**6. Data for Performance Comparisons** — The data to be stated for performance comparisons and for technical acceptance shall be as listed in Appendix B.

## 7. Performance Measuring and Testing

**7.1 Test Conditions** — Tests need constant working conditions (flow, temperature, pressure). These constant conditions shall be listed in the test report. Ideally, testing shall be carried out under the working conditions specified by the reference conditions and the chosen performance rating parameters required by the specification, but this is often neither practicable nor economic so that test results have to be converted.

**7.2 Conversion of Test Results** — Test conditions and results seldom agree exactly with the reference conditions and the selected performance rating parameters. Therefore, before the test results and the contract values are compared, conversions shall be made to allow a proper comparison.

**7.2.1** The practical conversion details shall be as agreed to between the purchaser and the supplier.

**7.3 Test Report** — See Appendix C.

**7.4 Test System for Air Dryers** — A diagram of a typical testing system for air dryers and notes on the symbols used shall be as given in Appendix D.

**7.5 Saturation Pressure and Density of Pure Water Vapour** — See Appendix E.

### 7.6 Measuring Equipment and Accuracy

**7.6.1 Flow** — Flow rates shall be measured to an accuracy of  $\pm 2$  percent, for example:

- a) with calibrated flow meter,
- b) with orifice or nozzles, and
- c) by observing the time needed to fill a vessel of known volume (for liquids only).

**7.6.2 Temperature** — Temperature shall be measured to an accuracy of  $\pm 0.5^\circ\text{K}$ .

**7.6.3 Pressure/pressure drop** — Pressure and pressure drop shall be measured to an accuracy of  $\pm 2$  percent.

**7.6.4 Pressure dew point** — The pressure dew point shall be measured at the dryer outlet. The measuring instrument used shall have the accuracy indicated in Table 3.

TABLE 3 ACCURACY OF DEW POINT MEASUREMENT

Dew Point Range °C	Accuracy
-100 to below -40	$\pm 2$
-40 to below -10	$\pm 1$
-10 and above	$\pm 0.5$

**7.6.5 Electric power** — Electric input power, including all parts and components of the dryer, shall be included in the electric power consumption test, and shall be measured with a calibrated wattmeter or in the case of three-phase electric motors, in accordance with the two-wattmeter method. The instrument(s) shall at least be of Class 1 accuracy.

**7.6.6 Other requirements** — Consumption of steam, water, etc, which are needed for working purposes shall be measured in accordance with 7.

**7.6.7 Refrigeration dryers** — The total input power to the complete unit shall be measured in accordance with 7.6.5 over a suitable period.

**7.6.8 Heatless dryers** — The bleed air volume and the dump losses together with other energy requirements shall be measured while operating under constant working conditions.

**7.6.9 Heat regenerated dryers** — When electricity, steam, hot water, etc, are used as source of regeneration heat, the energy consumption shall be reported in kilowatt hours per full drying cycle, and the nominal cycle time stated. Bleed flow rate and total consumption of bleed air shall be stated.

**7.6.10 General examination** — With pressure applied, the unit shall be examined for damage and leaks while under pressure; the items listed in the test report shall be entered as appropriate.

**7.6.11 Acceptance test** — The extent and cost of any such test shall be agreed between the purchaser and the supplier at the time of the contract.

## **8. Guarantee**

**8.1** The usable capacity of the dryer, when delivering the guaranteed pressure dew point and working at the specified conditions, shall not fall below the guaranteed value by more than 5 percent.

**8.2** The total energy requirement of the dryer, divided by the corresponding usable volume delivered, shall not exceed the value calculated from the guaranteed performance by more than 5 percent.

**8.3** The pressure drop over the complete dryer shall not exceed the guaranteed value by more than 10 percent.

**9. Certification Marking** — Details available with the Bureau of Indian Standards.

## APPENDIX A

(Clause 5)

## USER DATA

SI No.	Description	Symbol	Unit	Remarks
1.	Compressor type	—	—	The type of compressor(s) (for example, displacement or turbo compressor), the type of lubrication (oil-free, minimum lubrication or oil floods) and the type of coolant (air, water, oil).
2.	Mode of operation of compressor plant	—	—	Continuous/intermittent
3.	Volume of air receiver	V	$\text{m}^3$	
4.	Air volume flow rate related to the intake conditions in compliance with 2.10.1	$G_{v1}$	l/s	The maximum volume flow of air accepted by the dryer under the reference conditions including air required for regeneration, pressurizing or cooling purposes.
5.	Effective (gauge pressure of the compressed air)	$p_1$	bar	
6.	Temperature of compressed air	$t_1$	°C	The temperature of compressed air at the inlet of the dryer that affect its performance.
7.	Pressure dew point of compressed air	$t_{pd1}$	°C	If the dryer is installed immediately following the compressor after-cooler the compressed air may be assumed to be saturated. However, the humidity of the air shall be measured if the dryer is installed downstream of the air receiver or in the pipework remote from the aftercoolers.
8.	Oil presence in compressed air	—	—	Yes/No
9.	Aggressive components in air	—	—	The purchaser shall state the type and an amount of compressor lubricated at the dryer inlet.
10.	Coolant	—	—	
11.	Coolant temperature	$t_{cool}$	°C	Water/air
12.	Coolant quality	—	—	
13.	Coolant pressure	—	bar	See SI No. 9

Sl No.	Description	Symbol	Unit	Remarks
14.	Position of air dryer	—	—	Before/ after air receiver When designing and specifying the air dryer, the position of the air receiver is important.
15.	Dryer location	—	—	Indoors/ outdoors
16.	Ambient conditions (Maximum and minimum)	—	—	
17.	Power available	—	—	Supply frequency

**APPENDIX B**  
(Clause 6 and Table 2)  
**SUPPLIER DATA FOR PERFORMANCE COMPARISONS**

SI No.	Description	Symbol	Unit	Remarks
1.	Type of compressed air dryer	—	—	Specific details with regard to operation and design/type of the compressed air dryer shall be given as well as a specification of the equipment included in the delivery.
2.	Mode of operation of compressed air dryer	—	—	Details shall be provided of the mode of operation of the compressed air dryer, for example, continuous operation, or off operation (for refrigeration dryers), alternating operation (in the case of adsorption dryers) as well as automatic, semi-automatic or manual.
3.	Mass flow of compressed air (if required)	$q_{m2}$	kg/s	The volume of air delivered by the dryer under the reference conditions, that is, after maximum bleed air, pressurizing air and cooling air flows have been deducted.
4.	Air volume flow rate related to the intake condition	$q_{v2}$	l/s	If required, the manufacturer of the dryer shall calculate the mass of flow from the volume flow and state the value in the tender.
5.	Temperature of dried compressed air	$t_2$	°C	The temperature shall be measured.
6.	Highest pressure dew point under operating condition	$t_{pd}$	°C	The maximum pressure dew point shall be stated for operating conditions.
7.	Nominal pressure dew point as requested by purchaser	$t_{pd}$	°C	—
8.	Coolant flow	$q_{ycool}$	l/s	—
9.	Energy requirements	—	—	—
10.	Electric power at dryer terminals including all components (this includes cooling air fans), maximum and average	—	kW	—
11.	Bleed air, dump losses, etc, maximum and average	$q_y$ loss	l/s	—
12.	Steam consumption	—	l/s (or kg/h)	—
13.	Steam condition: a) Pressure b) Temperature	—	bar °C	—
14.	Water (for cooling according to coolant temperature which is used at any heat exchange of dryer)	$q_v$	l/s	—
15.	Noise level of air dryer	—	dB	—

**Note**—In addition to the reference conditions (see Table 1, including options A or B) and the performance rating parameters (see Table 2), additional data shall be available when making performance comparisons.

**A P P E N D I X C**

*(Clause 7.3)*

**TEST REPORT FORM**

- 
1. Customer: .....
  2. Dryer Type: .....
  3. Model No.: .....
  4. Serial No.: .....
  5. Customer Order No.: .....
- 

**a) Construction Requirements**

6. Pressure vessel code: .....
7. Electrical codes: .....
8. Required approvals: .....
9. Others (pressure relief valves, etc) .....

**b) Installation Requirements**

10. Electrical power connection: .....
11. Internal control wiring; control voltage for instruments and signal lamps: .....
12. Connection for compressed air—Size and type: .....
13. Connection for cooling water—Size and type: .....
14. Required ancillary components for satisfactory operation (for example, filters, additional heat-exchangers, fans, etc.): .....
15. Dryer installed before or after the air receiver: .....

**c) Instrumentation and Accessories**

15. Pressure gauges: .....
16. Thermometers: .....
17. Dew point instruments: .....
18. Signal lamps: .....
19. Others (pressure switches, main switch, etc): .....

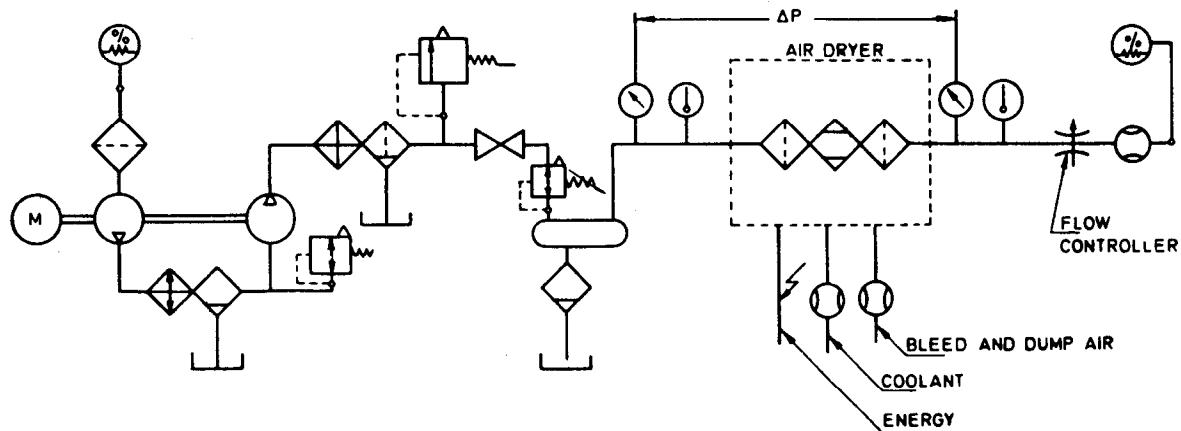
**d) Results**

- i) General examination
- ii) Compressed air — inlet temperature: .....
- outlet temperature: .....
- pressure dew point: .....
- iii) Pressure drop over dryer .....
- iv) Energy requirements .....
- v) Noise level .....

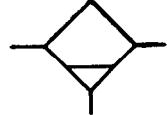
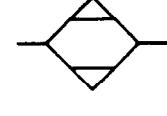
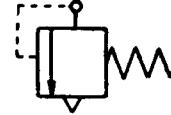
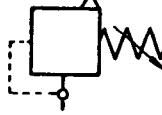
- e) Inspecting Agency .....

Date/Signature

**APPENDIX D**  
*(Clause 7.4)*  
**TYPICAL TESTING SYSTEM FOR AIR DRYERS**



SI No.	Definitions	Graphic Symbol
1.	Electric motor	
2.	Compressor	
3.	Pressurized receiver	
4.	Open tank	
5.	Filter	
6.	Cooler	

Sl. No.	Definitions	Graphic Symbol
7.	Water trap	
8.	Dryer	
9.	Safety valve	
10.	Shut-off valve	
11.	Pressure gauge	
12.	Thermometer	
13.	Flow meter	
14.	Flow controller	
15.	Pressure regulator or reducing valve	
16.	Humidity or dew point measurement	

## APPENDIX E

(Clause 7.5)

## SATURATION PRESSURE AND DENSITY OF PURE WATER VAPOUR

$t$ °C	$p_s$ mbar	$e_w$ g/m <sup>3</sup>
-100	1.403	1.756
-99	1.719	2.139
-98	2.101	2.599
-97	2.561	3.150
-96	3.117	3.812
-95	3.784	4.002
-94	4.584	5.544
-93	5.542	6.668
-92	6.685	7.996
-91	8.049	$\times 10^{-5}$ 9.574 $\times 10^{-5}$
-90	9.672	11.44
-89	11.60	13.65
-88	13.88	16.24
-87	16.58	19.30
-86	19.77	22.89
-85	23.53	27.10
-84	27.96	32.03
-83	33.16	37.78
-82	38.25	44.49
-81	46.38	52.30
-80	0.547 3	0.613 8
-79	0.644 4	0.719 1
-78	0.757 7	0.841 3
-77	0.889 4	0.982 4
-76	1.042	1.145
-75	1.220	1.331
-74	1.425	1.550
-73	1.662	1.799
-72	1.936	2.085
-71	2.252	2.414
-70	2.615	2.789
-69	3.032	3.218
-68	3.511	3.708
-67	4.060	4.267
-66	4.688	$\times 10^{-3}$ 4.903 $\times 10^{-3}$
-65	5.406	5.627
-64	6.275	6.449
-63	7.159	7.381
-62	8.223	8.438
-61	9.432	9.633
-60	10.80	10.98
-59	12.36	12.51
-58	14.13	14.23
-57	16.12	16.16
-56	18.38	18.34
-55	20.92	20.78
-54	23.80	23.53
-53	27.03	26.60
-52	30.67	30.05
-51	34.76	33.90
-50	39.35	38.21
-49	44.49	42.01
-48	50.26	48.37
-47	56.71	54.33
-46	63.93	$\times 10^{-3}$ 60.98 $\times 10^{-3}$
-45	71.93	68.36
-44	80.97	76.56
-43	90.08	85.65
-42	102.1	95.70
-41	114.5	106.9
-40	0.128 3	0.119 2
-39	0.143 6	0.139 2
-38	0.160 6	0.148 0
-37	0.179 4	0.164 6

$t$ °C	$p_s$ mbar	$e_w$ g/m <sup>3</sup>
-36	0.200 2	0.182 0
-35	0.223 2	0.203 2
-34	0.248 8	0.225 4
-33	0.276 9	0.249 4
-32	0.307 9	0.276 7
-31	0.342 1	0.306 1
-30	0.379 8	0.338 5
-29	0.421 3	0.373 9
-28	0.466 9	0.412 7
-27	0.517 0	0.455 1
-26	0.572 0	0.501 5
-25	0.632 3	0.552 1
-24	0.698 5	0.607 5
-23	0.770 9	0.667 8
-22	0.850 2	0.733 6
-21	0.937 0	0.805 3
-20	1.032	0.883 5
-19	1.135	0.967 8
-18	1.248	1.060
-17	1.371	1.160
-16	1.506	1.269
-15	1.652	1.367
-14	1.811	1.515
-13	1.984	1.653
-12	2.172	1.803
-11	2.376	1.964
-10	2.597	2.139
-9	2.837	2.323
-8	3.007	2.532
-7	3.379	2.752
-6	3.625	2.990
-5	4.015	3.246
-4	4.372	3.521
-3	4.757	3.817
-2	5.173	4.136
-1	5.623	4.479
0	6.108	4.487
1	6.566	5.192
2	7.055	5.559
3	7.575	5.947
4	8.129	6.360
5	8.719	6.797
6	9.347	7.260
7	10.01	7.750
8	10.72	8.270
9	11.47	8.819
10	12.27	9.933
11	13.12	10.01
12	14.02	10.66
13	14.97	11.35
14	15.98	12.07
15	17.04	12.83
16	18.77	13.63
17	19.37	14.48
18	20.63	15.37
19	21.96	16.31
20	23.37	17.30
21	24.86	18.34
22	26.43	19.43
23	28.09	20.58
24	29.83	21.78
25	31.67	23.05
26	33.61	24.38
27	35.65	25.78
28	37.30	27.22
29	40.06	20.78
30	42.43	30.38

$t$ °C	$p_s$ mbar	$e_w$ g/m <sup>3</sup>
31	44.93	32.07
32	47.55	33.83
33	50.32	35.68
34	53.20	37.61
35	54.24	39.63
36	56.42	41.75
37	62.76	43.96
38	66.26	46.26
39	69.93	48.67
40	73.78	51.19
41	78.80	53.82
42	82.02	56.56
43	86.42	59.41
44	91.03	62.39
45	95.86	65.50
46	100.9	68.73
47	106.2	72.10
48	111.7	75.61
49	117.4	77.26
50	123.4	83.06
51	129.7	87.01
52	136.2	91.12
53	143.0	95.39
54	150.1	99.83
55	157.5	104.4
56	165.2	109.2
57	173.2	114.2
58	181.5	119.4
59	190.2	124.7
60	199.2	130.2
61	208.6	135.9
62	218.4	141.9
63	228.5	148.1
64	230.1	154.5
65	250.1	161.2
66	261.5	168.1
67	273.3	175.2
68	285.6	182.6
69	298.4	190.2
70	311.6	198.1
71	325.3	206.3
72	339.6	214.7
73	354.3	223.5
74	369.6	232.5
75	385.5	241.8
76	401.9	251.5
77	418.9	261.4
78	436.5	271.7
79	454.7	282.3
80	473.6	292.3
81	493.1	304.6
82	513.3	316.3
83	534.2	328.3
84	556.7	340.7
85	578.0	353.5
86	601.0	366.6
87	624.9	380.2
88	649.5	394.2
89	674.9	400.6
90	701.1	423.5
91	728.2	438.8
92	756.1	454.5
93	784.9	470.7
94	814.6	487.4
95	845.3	504.5

$t$ °C	$p_s$ mbar	$e_w$ g/m <sup>3</sup>
96	876.9	522.1
97	909.4	540.3
98	943.0	558.9
99	977.6	578.1
100	1 013.2	587.8
101	1 050	618.0
102	1 088	638.8
103	1 127	660.2
104	1 167	682.2
105	1 208	704.7
106	1 250	727.8
107	1 294	751.6
108	1 339	776.0
109	1 385	810.0
110	1 433	826.7
111	1 481	853.0
112	1 532	880.0
113	1 583	907.7
114	1 636	936.1
115	1 691	965.2
116	1 746	995.0
117	1 804	1 026
118	1 863	1 057
119	1 923	1 089
120	1 985	1 122
121	2 049	1 150
122	2 114	1 190
123	2 182	1 225
124	2 250	1 262
125	2 321	1 299
126	2 393	1 337
127	2 467	1 375
128	2 543	1 415
129	2 621	1 456
130	2 701	1 497
131	2 783	1 540
132	2 867	1 583
133	2 953	1 627
134	3 041	1 673
135	3 131	1 719
136	3 223	1 767
137	3 317	1 815
138	3 414	1 865
139	3 512	1 915
140	3 614	1 967

## EXPLANATORY NOTE

In the preparation of this standard, assistance has been derived from ISO/DIS 7183 'Compressed air dryers—Specifications and testing', issued by the International Organization for Standardization.